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THREE AGES OF VENUS

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A central question for any planet is the age of its surface. Based on comparative planetological arguments, Venus should be as young and active as the Earth (Wood and Francis, 1988). The detection of probable impact craters in the Venera radar images provides a tool for estimating the age of the surface of Venus. Assuming somewhat different crater production rates, Bazilevskiy et al. (1987) derived an age of 1 ± 0.5 billion years, and Schaber et al. (1987) and Wood and Francis (1988) estimated an age of 200-400 million years. The known impact craters are not randomly distributed, however (Wood and Francis, 1988; Plaut and Arvidson, 1988), thus some areas must be older and others younger than this average age.

We have derived ages for major geologic units on Venus using the Soviet catalog of impact craters (Bazilevskiy et al., 1987) and the most accessible geologic unit map (Bazilevskiy, 1989). Table 1 presents the crater counts (diameters >20 km), areas, and crater densities for the 7 terrain units and coronae. Our procedure for examining the distribution of craters is superior to the purely statistical approaches of Bazilevskiy et al. (1987) and Plaut and Arvidson (1988) because our bins are larger (average size 16 x 10^6 km^2) and geologically significant.

Crater densities define three distinct groups: relatively heavily cratered (Lakshmi, mountain belts), moderately cratered (smooth and rolling plains, ridge belts, and tesserae), and essentially uncratered (coronae and domed uplands). Following Schaber et al. (1987), we use Grieve's (1984) terrestrial cratering rate of 5.4 ± 2.7 craters >20 km/10^9 years/10^6 km^2 to calculate ages for the geologic units on Venus. To improve statistics we aggregate the data into the three crater density groups, deriving the ages in Table 2. For convenience, the three similar age groups are given informal time stratigraphic unit names, from youngest to oldest: Ulfrunian, Sednaian, Lakshmian.

These results suggest that (1) there are significant differences in the age of units on the surface of Venus, (2) the age differences are geology dependent (not random), (3) some activity is extraordinarily young, and (4) geologic activity on Venus may be episodic rather than continuous, i.e periods of activity were centered at 330, 150 and 10 m.y. ago. This is different, for example, from the generally continuous seafloor spreading that has occurred on Earth for the last 150 m.y. Changes in the pace of activity are also pronounced (Table 2), with approximate resurfacing rates (in 10^6 km^2/10^9 yr) of 10 during the Lakshmian, 700 during the Sednaian, and 400 during the Ulfrunian.

The derived ages and photogeologic observations provide evidence concerning the stratigraphic relations of various units. **(a)** Recent volcanism (Bazilevskiy et al., 1989) cuts all units except tesserae, and coronae (also though to be volcanic; Stofan et al., 1988) cut all but tesserae and Lakshmi and surrounding mountains. The lack of these recent volcanic landforms on tesserae suggest that either magma generation does not occur under them or that magma can not rise to the surface (thick or low density crust?). **(b)** Mountain belts surrounding Lakshmi are old; the deformation forming them is thus ancient and not contemporary (or crater outlines would be distorted). **(c)** Ridge belts are the same age as (not younger than) the plains which surround them, thus they are not like active terrestrial spreading ridges which are commonly of zero age while nearby ocean floor may be tens of millions of years older. **(d)** Impact craters are not uniformly distributed within all terrains; some large areas of ridge belts and tesserae have no detected impact craters, and Lakshmi has most of its impacts concentrated in the western half. **(e)** The two youngest units - domed uplands and coronae - appear to be superposed on smooth and rolling plains and ridge belts. One corona cuts domed uplands, and small patches of domed uplands occur in the middle of tesserae.

The broadscale distribution of time stratigraphic units (Fig. 1) is not random. All but one patch of the young domed upland is south of roughly 40°N latitude, suggesting a younging toward the equator. Coronae, which are also very young, are widely dispersed in latitude and longitude. The oldest units (Lakshmi and mountain belts) are tightly clumped in one patch, almost like terrestrial Precambrian shields with surrounding greenstone belts.

All of these observations and inferences depend on the distribution of 96 craters >20 km in diameter on ~25% of Venus. Fortunately these speculations can be confirmed, extended or rejected when the higher resolution, full-planet radar images from Magellan become available.

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TABLE 1: CRATER STATISTICS

Terrain Unit	Number of Craters	Area ($10^6 km^2$)	Craters /Area
Domed Uplands	0	5.1	0.0
Coronae	0.5	2.3	0.2
Rolling Plains	74	55.8	1.3
Smooth Plains	22	24.8	0.9
Ridge Belts	17.5	13.4	1.3
Tesserae	13	12.6	1.1
Lakshmi	6	2.0	3.0
Mountain Belts	5	1.3	3.8

TABLE 2: TIME -STRATIGRAPHIC UNITS

Unit	Time-stratigraphic Name	Age [1]	Resurfacing Rate [2]
Domed Uplands Coronae	Ulfrunian	13	392
Rolling Plains Smooth Plains Ridge Belts Tesserae	Sednaian	150	710
Lakshmi Mountain Belts	Lakshmian	330	10

Units: 1: 10^6 yr; 2: $10^6 km^2/10^9$ yr

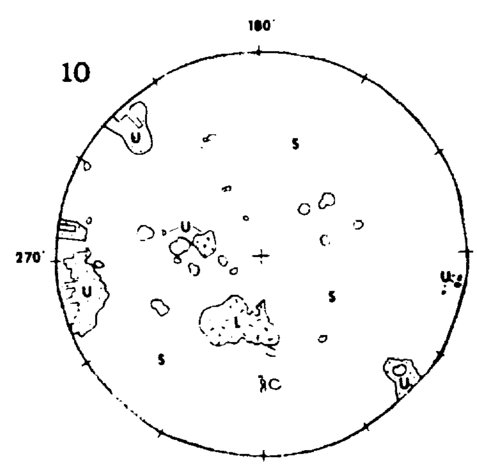

Fig.1: Time-stratigraphic map of northern portion of Venus. U = Ulfrunian (age 10 m.y.); S = Sednaian (150 m.y.), L = Lakshmian (330 m.y.). Unlabeled outlines are Coronae of Ulfrunian age.